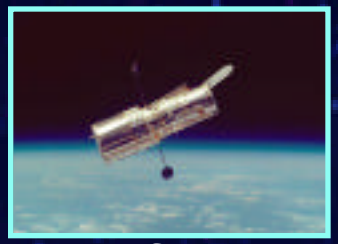
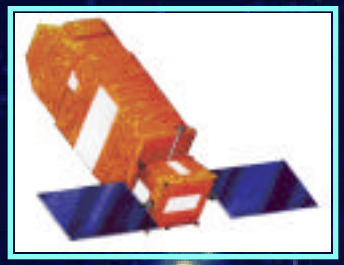
Astronomical Search for Origins

The Missions

Telescopes

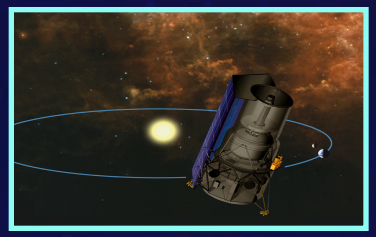


HST



FUSE

SOFIA



SIRTF

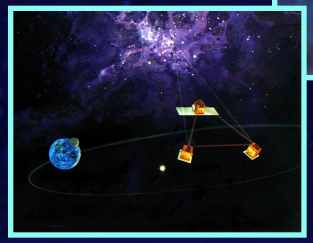
WIRE

NGST

Interferometers

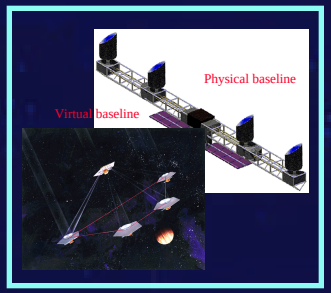
PTI

Keck

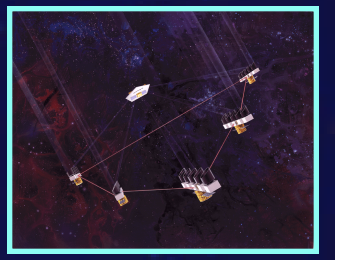


DS-3

SIM



TPF



TPI

http://www.stsci.edu/hst/

HST *Hubble Space Telescope*

Salient Features

- A 2.4 m optical astronomical observatory and its instruments operating above the Earth's atmosphere
  - 600 km low Earth orbit; 97-minute orbit
  - 15.9 m long; 4.2 m in diameter; 11,000 kg
  - Wavelength range: 0.1 to 2.5 microns
- First long-term, maintainable and repairable space observatory - a NASA/European Space Agency partnership
  - International general user facility
  - Over 300 guest observer proposals executed yearly

Science

- **Space Telescope Imaging Spectrograph (STIS)**
  - STIS brings 2-dimensional spectroscopy to HST for first time
  - Performance continues to exceed specifications; astronomical community is highly enthusiastic about data quality
  - Science results in last 6 months include: afterglow of gamma-ray burst and underlying galaxy, gravitational arcs around X-ray galaxy clusters, fine structural details in Jovian & Saturnian aurorae, shock physics of supernovae and interaction w/ surroundings
- **Near Infrared Camera and Multi-Object Spectrometer (NICMOS)**
  - NICMOS brings Near-IR capability to HST for first time
  - Despite reduction of cryogen lifetime due to thermal short, science results are outstanding and instrument is much-used
  - Science results in last 6 months include: cloud formations in Jovian and Uranian atmospheres, detailed structure in planetary nebulae, supermassive black holes in active external galaxies, (possible) runaway ~ Jovian-size planet in binary star system
- **Wide-Field and Planetary Camera-2 (WFPC-2)**
  - WFPC-2 is still a unique imager in the UV and optical regions of spectrum
  - Although reaching "instrument middle age," WFPC-2 (b. 12/93) continues to be superb
  - Science results in last 6 months include: serendipitious detection of small/faint asteroids, star-bursting ring in core of external barred spiral galaxy, distant Type 1a supernovae/cosmological implications, warped circumstellar disk indicating possible planets

HST

Highlights over the past six months

- Cycle 7 observing with STIS, NICMOS, and WFPC-2 shows HST is more powerful than ever.
- Increase of NICMOS observing fraction to 40-50% has compensated for cryogen depletion in January '99, with impressive science results. Two NICMOS Camera 3 campaigns on Hubble Deep Field and other targets carried out successfully by moving HST secondary mirror.
- The NICMOS cryocooler, scheduled for installation in 2000 (3rd servicing mission), will allow detectors to run cold without cryogen. Cooler and subsystems have been built on rapid timescale and successfully tested on the ground. Test flight on Shuttle scheduled Oct. '98.
- Contractor build of Advanced Camera for Surveys (ACS; installation in 2000) nearly complete; delivery of instrument to GSFC scheduled Fall of '98 for integration and testing.
- Continued definition of Cosmic Origins Spectrograph (COS) and Wide-Field Camera-3 (WFC3), both to go on HST in 2003 (4th servicing mission). COS provides exceptional far-UV throughput far surpassing that of STIS. WFC3 backs-up ACS to 2010, with very high spatial resolution.

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Highlights for the next six months

- Continued preparation for 3rd servicing mission in 2000, which includes:
  - ACS, under development by Johns Hopkins Univ. & Ball Aerospace.
  - NICMOS cryocooler, a pair of new solar arrays, a fine guidance sensor, and an advanced computer
  - Test of the cryocooler, ACS electronics, and advanced computer on Oct. '98 "HOST" shuttle flight.
- Continued development of COS and WFC3 for flight in 2003.
- Continuation of HST's world class program of broad-based astronomical inquiry.

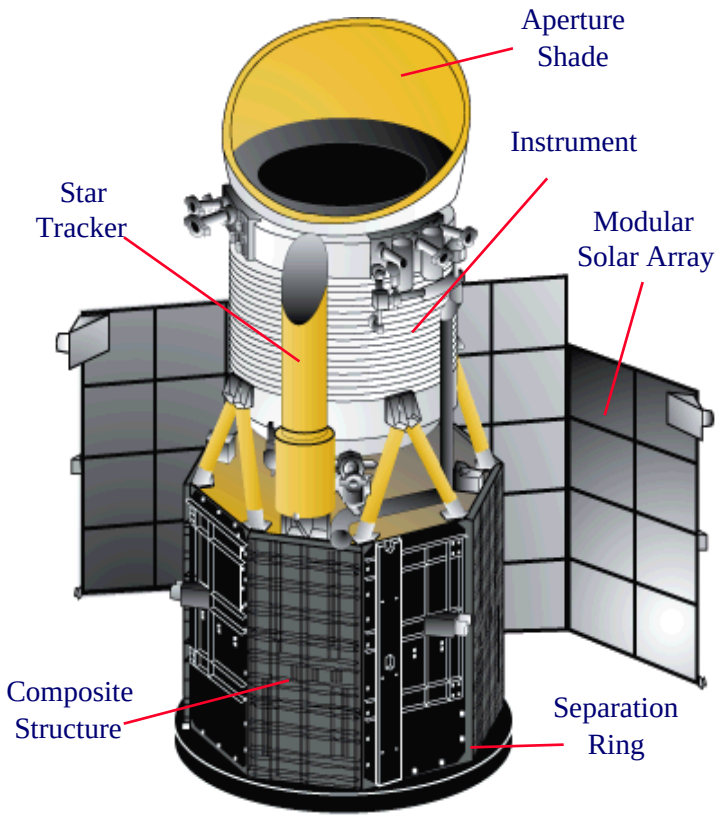
WIRE

Wide-field Infrared Explorer

http:// sunland.gsfc.nasa.gov/smex/wire/

Salient Features

- A cryogenically-cooled, two-color (12 μm & 25 μm) infrared imaging telescope
- A 30cm Ritchey-Chretien Cassegrain telescope
- Two 128x128 pixel, arsenic-doped silicon, Blocked Impurity Band (BIB) focal plane arrays at 12 μm & 25 μm
- Dual stage 7K/12K solid hydrogen cryostat
- Lifetime: 4-6 months
- Launch Date: 9/15/98



Science

- WIRE will study the evolution of starburst galaxies and search for protogalaxies. The primary scientific objectives are to answer the following three questions:
  - What fraction of the luminosity of the Universe at a redshift of 0.5 and beyond is due to the starburst galaxies?
  - How fast, and in what way, are starburst galaxies evolving?
  - Are luminous protogalaxies common at redshifts Z>0.5?

WIRE

Highlights over the past six months

- Completed second hydrogen test on flight instrument
- Completed environmental testing on WIRE flight instrument
- Final instrument optical alignment verified prior to shipment to GSFC
- Completed spacecraft environmental testing with instrument high fidelity thermal simulator
- WIRE Instrument pre-ship review completed
- Completed spacecraft bus environmental testing
- WIRE flight instrument delivered to Goddard Space Flight Center
- WIRE instrument integrated with spacecraft bus
- Observatory functionality verified

Highlights for the next six months

- Complete integrated WIRE observatory magnetic calibration: 6/98
- Complete End to End testing: 6/98
- WIRE Pre-Ship review: 7/98
- Ship to launch site: 7/98

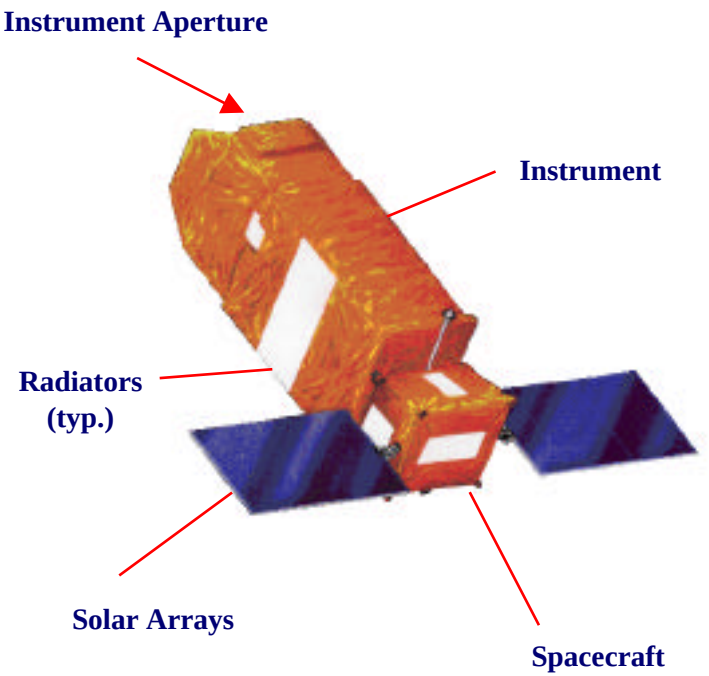
FUSE

Far Ultraviolet Spectroscopic Explorer

http://fuse.pha.jhu.edu/

Salient Features

- A far-ultraviolet spectroscope comprised of
  - Four co-aligned telescopes
  - Four high resolution, aberration corrected holographic diffraction gratings
  - Two delay-line microchannel plate detectors
- Wavelength coverage: 905-1195 Å
- Spectral resolution: better than .05 Å with a goal of .03 Å
- Lifetime: three years
- Launch Date: 2/99



Science

- FUSE will use high-resolution, far-ultraviolet spectroscopy to study physical processes governing three broad areas of astrophysics
- Origin and evolution of light elements in the early universe
  - Processes controlling the evolution of galaxies
  - Origin and evolution of stars and planetary systems
- Guest Observer Program: 25% first year, 45% second year, 60% third year

FUSE

Highlights over the past six months

- Spectrograph aligned and delivered to APL for instrument integration
- Instrument integration completed at APL
- Spacecraft integrated and delivered to APL for satellite integration
- Instrument and spacecraft mated to form complete satellite
- Ground station antenna and facility completed and tested
- Satellite Control Center completed at Johns Hopkins University, Baltimore

Highlights for the next six months

- Series of satellite comprehensive performance tests to begin (7/98)
- Environmental testing to begin at Goddard Space Flight Center (8/98)
- Thermal-vacuum simulations of in-orbit checkout and science operations (9/98)
- Ship satellite to Cape Canaveral (12/98)
- FUSE launch (2/99)

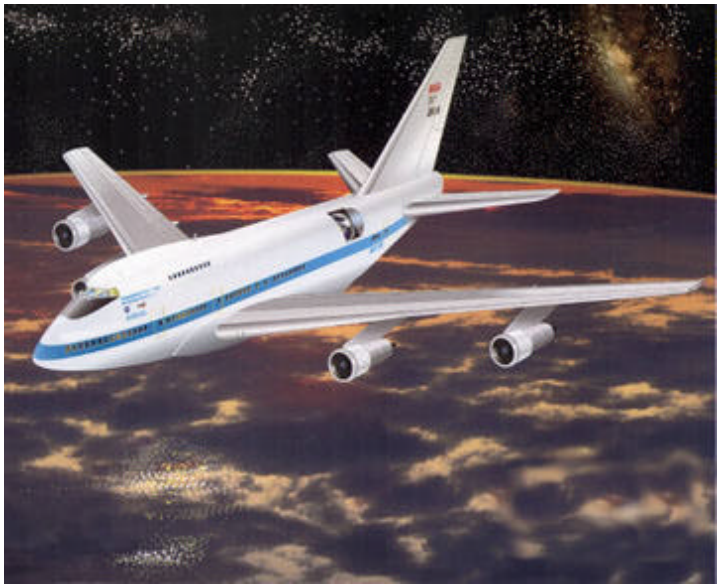
SOFIA

http://sofia.arc.nasa.gov/

Stratospheric Observatory for Far-Infrared Astronomy

Salient Features

- 2.5-meter, airborne telescope optimized for mid-to far-IR observations
- Total wavelength range 0.3μm to 1600 μm
- Stratospheric operation for over 6 hours per mission, 960 hours per year; 20+ years lifetime
- Image quality: 1.5 arcsec at 3-5 μm
- "First Light" in October 2001; numerous international focal plane instruments
- Collaboration with German Aerospace Center



Science

- Interstellar cloud physics and stellar birth in our galaxy
  - Importance of magnetic fields and rotation
- Protoplanetary disks and planet formation in nearby star systems
- Origin and evolution of biogenic atoms, molecules and solids
  - Environments hospitable to prebiotic molecules
- Composition and structure of comets, planetary atmospheres and rings
  - Solar nebula composition and solar system evolution
- The dynamic activity at the center of the galaxy
  - Power sources, and similarity to active galactic nuclei
- Luminosity mechanisms, dynamics, and interstellar processes in other galaxies

SOFIA

Highlights over the past six months

- Conducted Preliminary FAA Type Board meeting: 4/98
- Delivery of a 747SP Section 46 to Waco completed: 5/98
- SOFIA Operations Concept (including policies) approved: 5/98
- Conducted Telescope Assembly PDR in Germany: 6/98
- Conducted Science & Mission Operations Center CDR: 6/98
- Interface Control Documents between German and US systems baselined: 6/98

Highlights over the next six months

- Conduct Facility Science Instrument PDRs: 8/98
- Conduct SOFIA System PDR: 9/98 – 10/98
- Conduct Telescope Assembly CDR in Germany: 12/98
- Conduct Certification high speed wind tunnel test: 12/98

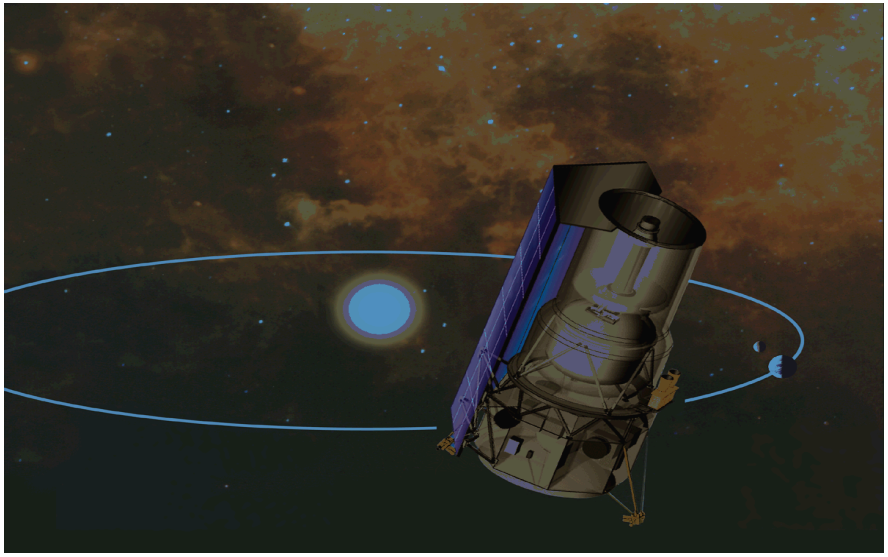
SIRTF

Space Infrared Telescope Facility

http://ssc.ipac.caltech.edu/sirtf

Salient Features

- Heliocentric orbit trailing the Earth
- 85cm Beryllium telescope operating at 5.5 K
- 3 instruments with 3-180 micron wavelength coverage operating at 1.5 K
- Launch date: December 1, 2001
- Operational life: >2.5 years (goal: 5 yrs.)
- Observing time available to scientific community: 80%



Science

- To search for brown dwarfs and super-planets, and to understand the contribution of sub-stellar objects to the mass of the Galaxy
- To study protoplanetary and planetary debris disks, and to assess the frequency of planetary-system formation around nearby solar-type stars
- To determine properties of ultra-luminous galaxies and active galactic nuclei, both nearby and in the distant Universe, and to understand the mechanisms which power these extremely energetic objects
- To study normal galaxies as they were when the Universe was less than one-quarter of its current size and age, and to understand how galaxies have evolved with cosmic time

SIRTF

Highlights over the past six months

- ***Project entered Development Phase in April. 3+ years to launch!***
- Began procurement & fabrication of flight detectors
- Completed metrology of proto-flight mirror in preparation for completion of figuring
- Began fabrication of critical flight instrument components (e.g., cryogenic scan mirror)
- Astronomical Observing Templates (AOTs) released for public comment
- Meeting at NASA-KSC to discuss launch vehicle interfaces
- Monthly meetings between SIRTF Science Center (SSC) and Instrument Teams begun.
- Inaugural meeting of SSC Oversight Committee (Neta Bahcall, Chair) on May 11-12
- SIRTF Education & Public Outreach (EPO) Plan endorsed by HQ on April 28

Highlights for the next six months

- Subsystem / system / facility Critical Design Reviews (CDRs)
- Complete planning for end-to-end Flight & Science Operations
- Begin testing of flight detectors & complete cryo-testing of re-figured (flight) primary mirror
- Complete initial plan for In-Orbit Checkout (IOC)
- Host science conference, *Astrophysics with IR Surveys: A Prelude to SIRTF*, on June 22-24
- Host a 1-day SIRTF Users Workshop on June 25
- Redesigned WWW site to debut at SSC in June
- SIRTF Project CDR in September, 1998

NGST

Next Generation Space Telescope

http://ngst.gsfc.nasa.gov/

Salient Features

- Near-infrared telescope with an 8-m class aperture
- Optimized for 1-5 μm (goal of 0.5-30 μm)
- Passive cooling < 50 K
- Possible orbits: L2, 3 AU, or above the ecliptic
- Wide-field camera and multi-object spectrograph
- Zodiacal-background-limited detector sensitivity
- 5-year lifetime (10-year goal)

Science

- NGST will provide major pieces of the puzzle currently missing from the picture of the Universe evolution from the Big Bang to the current epoch
  - NGST will
    - See the first stars and galaxies
    - Determine the shape of the Universe and shed light on its eventual fate
    - Map the chemical evolution of the Universe by observing the first supernovae
    - Observe debris disks around nearby stars

NGST

Highlights over the past six months

- Competitively selected 6 science instrument concepts for further study
- NGST Mirror Systems Demonstrator (NMSD) CDRs held and mirror fabrication started
- Continued partnering discussions with ESA on a $200M (US) contribution to NGST and with the Canadian Space Agency on a $50M (US) contribution
- Special SPIE conference held on NGST in Kona, Hawaii;
  Technology Challenge West conference held in California in June, over 150 attendees;
  ESA sponsored "*Science with the NGST*" conference held in Liege, Belgium in June
- First meeting of the NGST Standing Review Board in January
- Mirrors ground and polishing started for a ground testbed to demonstrate phasing and active wavefront control of a segmented telescope system
- Partnership discussions with DOD have identified several areas for cooperation/coinvestment

Highlights for the next six months

- Award of Advanced Mirror Concept demonstrator
- Initial operation of the ground testbed to demonstrate phasing and active wavefront control of a segmented telescope system
- Science PNAR on science program and instrumentation in the fall
- Second meeting of the NGST Standing Review Board will be in September

Keck Interferometer

http://huey.jpl.nasa.gov/keck/

Salient Features

- The two 10-m Keck telescopes + four 1.8-m outrigger telescopes
- 85-meter baseline between the two Kecks, 115 m outrigger baseline
- Wavelength: 2 μm and 10 μm
- Imaging resolution: 3 mas at 2 μm
- Astrometric accuracy: 20 μas
- Two-element commissioning: mid-2000
- Six-element array commissioning: mid- 2002

Science

- Direct detection of brown dwarfs and warm Jupiters (Jupiter-mass planets in close orbits)
- Null the starlight and study zodiacal clouds around nearby stars
  - This data is needed for the TPF design
- Indirect detection of Uranus-size planets via astrometry
- High-resolution imaging of protostellar disks in which planets may be forming

The first two objectives can be met with only the two Kecks connected as an interferometer.
The next two require the additional baselines provided by the outrigger telescopes.

Keck Interferometer

Highlights over the past six months

- Held Preliminary Design Review (PDR) 9/97
- Descoped to 4 (from 5), fixed (from movable) outriggers to increase funds reserve to ≈ 20%.
- Science review by Origins Subcommittee Task Force (Burke)
- Permitting:
  - Test siderostat permit request complete; will be used during the development
  - Univ. of Hawaii decided new master plan is needed – It will include the outriggers
- Documents prepared: Project Plan, Implementation Plan, JPL/CARA MOU, Science Requirements, Siderostat & Outrigger Reqt's, Operations White Paper
- Detailed outrigger specifications complete
- RFP for outriggers sent – 5 initial responses received, 3 proposals received
- Some AO hardware components ordered
- New Mauna Kea site survey and CAD drawings of site
- Draft Operations Plan and preliminary costs prepared
- PTI has commissioned its second 110m baseline
  - Improved astrometry during next summer's observing season

Highlights over the next six months

- Subsystem CDRs and system CDR scheduled for summer '98
- Contractor selection for the outrigger telescopes; initiate contract
- Start procurement for outrigger domes
- Obtain permit for the test siderostats, begin site construction and procure siderostats
- Start construction of 2-way beam combiner hardware
- Start construction of Keck coude train and complete K2 AO mods

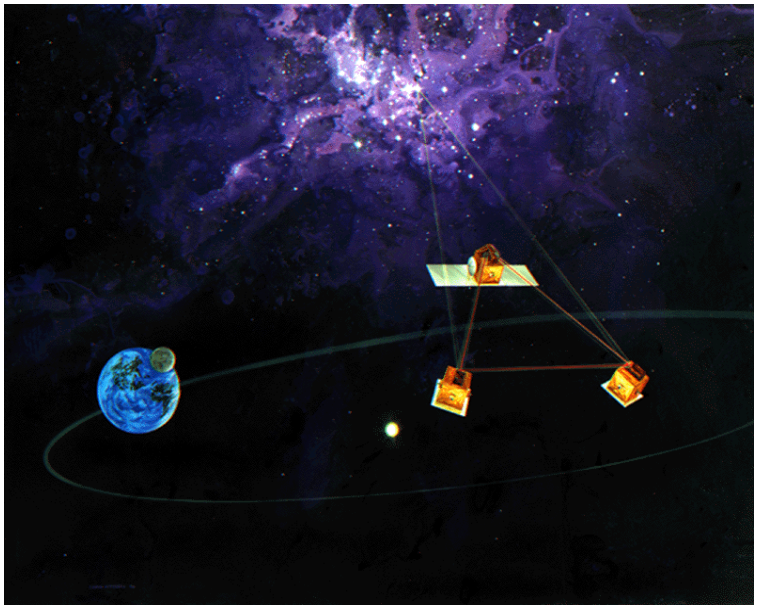
DS-3

Deep Space-3

http://huey.jpl.nasa.gov/nmi

Salient Features

- Space Optical Interferometer
  - Three S/C flying in formation
  - Two collectors, one combiner
  - 100 m to 1 km baseline
- Imaging resolution: 100 microarcsec (at 1 km)
- Launch December ‘02
- Heliocentric orbit (earth escape)
- Single Delta launch
- 6-month baseline mission



Technology

- Separated spacecraft optical interferometry
  - Space validation of many H/W and S/W elements for SIM as well as interferometer remote operations
- Precision formation flying, metrology system measures changes to 2nm, control to +/- 2 cm
  - Applicable to TPF

Science (Technology demonstrated through realistic science)

- Tidal distortion of a star’s photosphere due to a black hole orbiting the star
- Stellar Structure and evolution – diameters of hot stars, size/shape of peculiar stars

DS-3

Highlights over the past six months

- Spacecraft Cluster Draft RFP released
- Led and completed Joint Mission Study with a potential government sponsor
- Participated in State of Origins Review
- Instrument and Spacecraft Mission trades continued
- Project staffing of key positions is near completion

Highlights for the next six months

- Finalize and document “mission partner” collaboration agreement
- Continue technical work on reference mission
- Select industry partner
- Release Draft Level 1 requirements
- Release Draft Implementation Plan: 8/28
- Mission Confirmation Review planned for December time frame

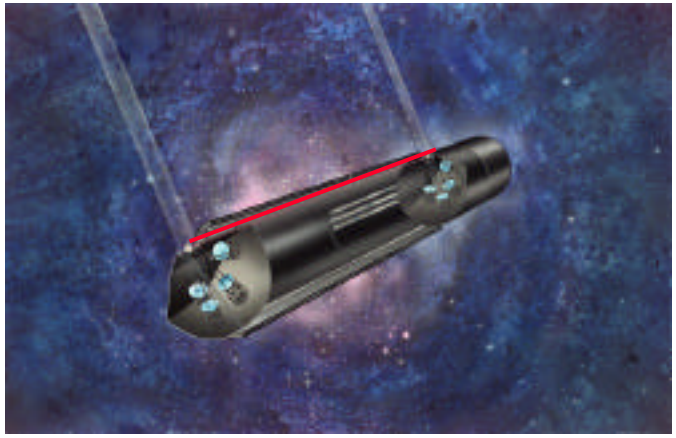
SIM

Space Interferometry Mission

http://huey.jpl.nasa.gov/sim/

Salient Features

- Optical Space Interferometer with 10-m baseline
- Path Length Control: Nanometer class
- Path Length Knowledge: Sub-Nanometer class
- Starlight Nulling: 10^{-4}
- Imaging Resolution: 10mas
- Astrometric Accuracy: 4 μas wide angle; 1 μas narrow angle
- Launch date: mid-2005



Science

- Indirect detection of planets outside the Solar System through observation of thousands of stars
- Improve on the best star positions in current catalogs by a factor of 250 and extend the sensitivity to stars a 1000 times fainter − application to ages and distances in the Universe
- Very high resolution (10 mas) imaging of broad range of astrophysical phenomena
- Study structure of planetary dust disks using starlight nulling imaging
- As co-equal objective to its science, SIM is also to be a technological pathfinder to the Terrestrial Planet Finder (TPF) mission

SIM

Highlights over the past six months

- Finalized industrial partnering strategy and issued RFP for two workpackages
  - Interferometer Partner and S/C-ATLO Partner
  - Total potential value ~$250M, Phase A through Phase E
  - Proposals due July 1
- Held Preliminary Instrument System Requirements Review
- Began a three-year collaboration with the University of Arizona to develop candidate nulling technologies
- Released NRA to develop SIM grid star catalog and other long-lead science

Highlights for the next six months

- Select industry partner(s) and negotiate contract(s)
- Complete testbed planning and cost-to-complete budget exercise
- Develop SIM Implementation Plan and prepare for its formal review
- Develop NRA for selection of the SIM Science Team
- Start definition of the SIM Science Data Center

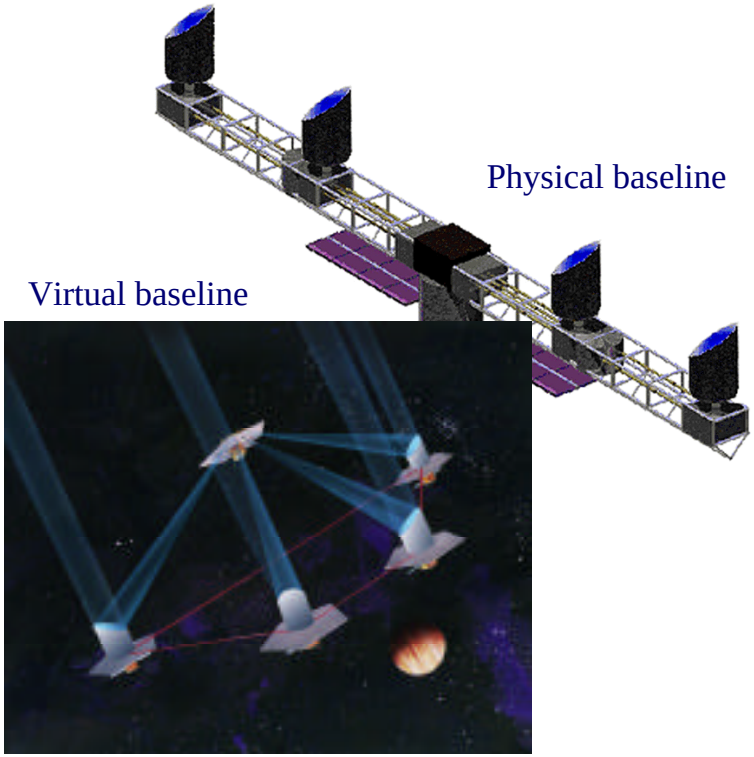
TPF

Terrestrial Planet Finder

http://origins.jpl.nasa.gov/missions/terrplfndr.html

Salient Features

- IR Interferometer (7-17 μm)
- Baseline: 75 m nominal
- Reference Design:
  - Orbit: 1 AU
  - Telescope Apertures: Two at 4.5m; two at 1.5m
  - Preferred Architecture: Separated S/C
  - Mission Duration: 5 years of observing
- Operating Temp. : < 35 K for all optical elements
- Target Launch: 2011 (Phase C/D target start: 2007)



Science

- Find and characterize Earth-like planets around other stars
  - Search neighboring 1,000 star systems
  - Characterize brightest planets
  - Detect broadband (resolution ~ 5) spectral signals in 1 hour
  - Detect spectral features (resolution ~ 20) in < 1 week
  - Perform imaging on select star systems in 6 weeks

TPF

Highlights over the past six months

- Awarded nulling technology development contract to University of Arizona
- Extended industry contract to address specific design space trade studies
- Initiated development of a technology roadmap
  - to show how SIM, NGST, DS-3 technologies flow into TPF
  - to identify means of technology validation
- Initiated development of modeling tools
- Initiated preparation of information for the next Astrophysics Decadal Committee
- Selected an *ad hoc* Science Definition Working Group – Frank Shu chair

Highlights for the next six months

- Develop detailed plan for nulling demonstration
- Perform top-level trade studies on candidate TPF concepts
- Complete new document entitled Roadmap To TPF
  - Update Science Objectives
  - Update technology roadmap
  - Update configurations
- Produce TPF fact sheet for general audience outreach